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Te[illegible] Report S[illegible] on the B[illegible]osystem-A[illegible]sphere Study (BOREAS)

[illegible]ll and Jaime Nickeson, Editors

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[illegible]AS RSS-3 Reflectance Measured [illegible]ounted Barnes MMR

[illegible]ll, S. Loechel, E. Brown de Colstoun

[illegible]nautics and
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July [illegible]

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NASA/TM—2000–209891, Vol. 46

Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall and Jaime Nickeson, Editors

Volume 46

BOREAS RSS-3 Reflectance Measured from a Helicopter-Mounted Barnes MMR

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BOREAS RSS-3 Reflectance Measured from a Helicopter-Mounted Barnes MMR

Charles L. Walthall, Sara Loechel, Eric Brown de Colstoun

Summary

The BOREAS RSS-3 team acquired helicopter-based radiometric measurements of forested sites with a Barnes MMR. The data were collected in 1994 during the three BOREAS IFCs at numerous tower and auxiliary sites in both the NSA and SSA. The 15-degree FOV of the MMR yielded approximately 79-m ground resolution from an altitude of 300 m. The MMR has seven spectral bands that are similar to the Landsat TM bands, ranging from the blue region to the thermal. The data are stored in tabular ASCII files.
The data are stored in tabular ASCII files.
Note: An extensive helicopter log (in Acrobat format) is available for the 1994 IFC's. Environmental, technical, instrumental, and operational conditions are noted for each observation where applicable. It is strongly recommended that any researcher doing extended work with this data set review this helicopter log.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS RSS-03 Reflectance Measured from a Helicopter-Mounted Barnes MMR

1.2 Data Set Introduction

Radiometer measurements of the BOReal Ecosystem-Atmosphere Study (BOREAS) forested tower and auxiliary sites in both the Northern Study Area (NSA) and Southern Study Area (SSA) were taken from a helicopter platform with a nadir viewing angle. The data were collected during the 1994 Intensive Field Campaigns (IFCs), which included the green-up, peak, and senescent stages of the growing season. The 15-degree field of view (FOV) of the Modular Multiband Radiometer (MMR) yielded an instantaneous field of view (IFOV) of approximately 79 m from the 300-m altitude typically flown. The MMR has seven spectral bands that are similar to the Landsat Thematic Mapper (TM) bands, ranging from the blue region to the thermal. MMR radiance and ground sunphotometer data were used as input to Version 3.2 of the Second Simulation of the Satellite Signal in the Solar Spectrum (6S) atmospheric correction software to obtain at-surface reflectance factors. The data are arranged in chronological order (date, time) and cover the period 31-May through 10-June (IFC-1), 21-July through 08-August (IFC-2), and 6-September through 16-September (IFC-3).

1.3 Objective/Purpose

The objective was to acquire multispectral, bidirectional reflectance, and surface temperature data of the study sites for assessments of spectral, spatial, and temporal variability and the impacts of these variabilities on vegetation indices. A helicopter with a pointable, stabilized mount was used to carry a spectrometer (visible and near-infrared), spectroradiometer, and a video camera. A sun-tracking photometer was also deployed to provide data for calculations of irradiance and for atmospheric correction of the data. Estimates of atmospheric conditions were not available from the onboard sunphotometer at the time that this data set was processed; therefore, the latest available version of the 6S atmospheric model was used for the calculations of irradiance and for atmospheric corrections.

1.4 Summary of Parameters

Helicopter-based measurements of at-surface and at-sensor reflectance, and at-sensor radiance values acquired at tower and auxiliary sites during all three 1994 BOREAS IFCs.

1.5 Discussion

These measurements were collected as part of the effort to evaluate models that estimate surface biophysical characteristics from remotely measured optical signatures.

1.6 Related Data Sets

BOREAS RSS-01 PARABOLA SSA Surface Reflectance and Transmittance Data
BOREAS RSS-02 Level-1b ASAS Imagery: At-sensor Radiance in BSQ Format
BOREAS RSS-03 Reflectance Measured from a Helicopter-Mounted SE-590
BOREAS RSS-03 Atmospheric Measurements from a Helicopter-Mounted Sunphotometer
BOREAS RSS-03 Video Imagery Acquired from a Helicopter Platform
BOREAS RSS-11 Ground Network of Sunphotometer Measurements
BOREAS RSS-12 Automated Ground Sunphotometer Measurements in the SSA
BOREAS RSS-19 1994 Seasonal Understory Reflectance Data
BOREAS RSS-20 POLDER Measurements of Surface BRDF

2. Investigator(s)

2.1 Investigator(s) Name and Title

Dr. Charles L. Walthall, Physical Scientist

2.2 Title of Investigation

Biophysical Significance of Spectral Vegetation Indices in the Boreal Forest

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3. Theory of Measurements

Light radiation striking a vegetative canopy interacts with individual phytoelements (leaves, stems, branches) and the underlying substrate. The interaction depends on light quality, radiative form (direct or diffuse), illumination incidence angle, vegetative component optical properties, and canopy architecture. Radiation is reflected, transmitted, or absorbed.

The helicopter missions were designed to provide a rapid means of intensively spectrally characterizing vegetative cover at the BOREAS sites and to provide an intermediate scale of sampling between spectral measurements made at the surface and those made from higher altitude aircraft and spacecraft multispectral imaging devices. The MMR instrumentation was chosen to provide compatibility with surface-based radiometers and TM spacecraft sensors.

4. Equipment

4.1 Sensor/Instrument Description

The primary instruments for the BOREAS deployment were the SE-590 Spectron Engineering spectroradiometer (SE-590), a Barnes MMR, a color Charge Coupled Device (CCD)-based video camera, and a sun-tracking photometer. The downward-looking sensor heads, along with a color video camera, were mounted on an operator-controlled pointable mount that allows control of the view zenith and view azimuth directions independent of the heading of the aircraft.

The MMR was developed in the late 1970s in response to the need for a field instrument for remote sensing by the National Aeronautics Space Administration (NASA) remote sensing community. Calibration considerations were integral to the design of this device. The device consists of eight sensors (four silicon and four lead sulfide detectors) with associated changeable optics for each. The serial number of the instrument used was 117.

The voltages from the MMR are digitized with the use of an 18-channel analog-to-digital (A/D) converter, the Travelogger. The Travelogger is a standalone A/D system that runs on AC power while in the helicopter and outputs digital data to the hard disk of a PC also controlling the SE-590 via an RS-232 cable.

For additional information on the instruments, see also Walthall et al. (1996) and Robinson et al. (1981).

4.1.1 Collection Environment

The helicopter was flown during relatively clear days when possible. Data collection was attempted during conditions of highest possible solar elevation. All observations were attempted from a nadir observation point and usually at 300 m above ground level (AGL). Exceptions are noted in the extensive helicopter log, which is available. Environmental, technical, instrumental, and operational conditions are noted for each observation where applicable.

4.1.2 Source/Platform

The UH-1 "Huey" series of helicopters has been available as a platform for the system in many field campaigns. The first 10 years of the system development and use were with two UH-1B Huey helicopters, while the aircraft used for BOREAS was a UH-1H model Huey helicopter. Wallops Flight Facility (WFF) changed to the H-model helicopter because of its increased payload capability, the availability of spare parts, and its widespread use by other organizations. The Bell UH-1H "Iroquois" helicopter, call-number N415, was built in 1965 and was acquired by WFF in 1993. Upon acquisition, the aircraft was slightly modified for use as a scientific platform.

Helicopter N415 operates with standard or low mount, rear-leaning skids. The engine is a Lycoming T53/L13, which provides 1,400 shaft HP with 1,290 transmission HP. The fuel capacity provides 2.0 hours of flying time with a 20-minute fuel reserve under normal modes of operation. The addition of an auxiliary fuel tank in the port-side door crewman's position provided an additional 15 minutes of flight time during BOREAS given optimum flight conditions.

The instrument platform controllers, power supplies, and data loggers are mounted on 54-inch-wide, 72-inch-high steel rack mounts fabricated at WFF. Three racks are situated directly in front of the instrument operators. Seats for the instrument operators are located across the front of the transmission and main rotor mast housing. Whenever possible, existing hard points are used for attaching hardware both internally and externally.

The weight of the entire helicopter system with full instrumentation, full fuel, and crew members is 9,500 lbs.

4.1.3 Source/Platform Mission Objectives

The helicopter missions were designed to provide a rapid means of intensively spectrally characterizing sites and to provide an intermediate scale of sampling between the surface measurements and the higher altitude aircraft and spacecraft multispectral imaging devices. The MMR instrumentation was chosen to provide compatibility with surface-based radiometers and TM spacecraft sensors.

4.1.4 Key Variables
Surface reflectance.

4.1.5 Principles of Operation
System Operation: Computer control of the instruments provides precise, automatic control and ensures proper timing of data collection. The radiometric instruments are configured such that all sensors except the photographic camera can be triggered near-simultaneously with a single computer keyboard keystroke. The command sent from the keyboard is first sent to the SE-590, then to the A/D systems. Raw data from each of the instruments are displayed via graphics and tabular listings on the main computer screen immediately after scanning.

The system is configured for multiple sensor data collection. The MMR, SE-590, infrared thermometer, autotracking sunphotometer, and video sensor were the primary payload during BOREAS. The voltages from the MMR are digitized with the use of an 18-channel A/D converter, a standalone A/D system that runs on AC power while in the helicopter and outputs digital data to a PC.

4.1.6 Sensor/Instrument Measurement Geometry
The NASA Goddard Space Flight Center (GSFC)/WFF helicopter-based optical remote sensing system was deployed to acquire canopy multispectral data with a Barnes MMR while hovering approximately 300 m AGL (Walthall et al., 1996). The 15-degree FOV of the MMR yielded a ground resolution of approximately 79 m at the nominal altitude of 300 m.

4.1.7 Manufacturer of Sensor/Instrument
MMR (this device is no longer in production)
Barnes Engineering Company
30 Commerce Road
Stamford, CT 07904

4.2 Calibration
Calibration of the MMR was performed according to the procedures described in Markham et al., 1988. Radiometric calibration and spectral calibration procedures were done before and after the field season to check for changes in sensor radiometric response. In-field calibration checks were periodically made with a large, portable integrating sphere system. This sphere was also used to calibrate the airborne instruments on other aircraft and some of the surface- based radiometric instrumentation. The MMR relative spectral response curves of the filters were well characterized prior to the field deployment.

4.2.1 Specifications
The Barnes MMR produces analog voltage responses to scene radiance in eight spectral bands and to the instrument chopper and detector temperatures. The eight wavebands are described below. Wavebands 1-4 have silicon detectors, wavebands 5-7 have lead sulfide detectors, and waveband 8 has a Lithium Tantalum trioxide detector. The MMR's dimensions are 26.4 cm by 20.5 cm by 22.2 cm, and it weighs 6.4 kg.

```
----------------------------
MMR        Wavelength Range
Channel       (microns)
----------------------------
1            0.45 -  0.52
2            0.52 -  0.60
3            0.63 -  0.69
4            0.76 -  0.90
5            1.15 -  1.30
6            1.55 -  1.75
7            2.08 -  2.35
8           10.40 - 12.50
```

4.2.1.1 Tolerance

Markham et al. (1988) summarize the calibration and instrument degradation during the First International Satellite Land Surface Climatology Project (ISLSCP) Field Experiment (FIFE):

"The changes in calibration of the MMR instruments were related to the extent of their use. In the silicon channels of the MMR, instruments used throughout the 4 field campaigns showed degradations of 3-4% between pre- and post-season calibrations. Strong temperature sensitivity in the lead-sulfide (PbS) channels, about +/-25% over a 15 °C range, which was reduced to +/-4% or less with temperature correction, led to greater uncertainty in these channels calibration... ."

Note that MMR bands 1-4 use silicon detectors, and bands 5-7 use lead-sulfide (PbS) detectors. Similar results are expected with the BOREAS calibrations.

4.2.2 Frequency of Calibration

Radiometric calibration and spectral calibration procedures were done before and after the field season to check for changes in sensor radiometric response. In-field calibration checks were periodically made with a large, portable integrating sphere system. This sphere was used to calibrate the airborne instruments on other aircraft and some of the surface-based radiometric instrumentation.

4.2.3 Other Calibration Information

None.

5. Data Acquisition Methods

The use of off-the-shelf field instruments aboard airborne platforms is a cost-effective and efficient approach to assembling a data collection system. The instruments are generally rugged enough for the harsh operating environment of a helicopter, provide data comparable to data sets on the surface, and are easy to use and versatile during operation. The system, developed jointly at NASA GSFC and WFF, uses several widely accepted field-portable radiometric instruments. The system is configured such that instruments from other investigators can be deployed on the helicopter with little or no interference with the primary instrument system. An autotracking sunphotometer system, developed specifically for use on helicopters, is the newest addition to the system.

The NASA GSFC/WFF helicopter-based optical remote sensing system was deployed to acquire canopy multispectral data with a Barnes MMR while hovering approximately 300 meters above ground level (Walthall et al., 1996). The 15-degree FOV of the MMR yielded an IFOV at this altitude of approximately 79 m. Observations were made over various tower and auxiliary sites during all three 1994 IFCs.

6. Observations

6.1 Data Notes

An extensive helicopter log is available. Environmental, technical, instrumental, and operational conditions are noted for each observation where applicable.

6.2 Field Notes

See Section 6.1.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

Each site listed in the following table was observed at least once during the 1994 campaigns. The given coordinates are based on the North American Datum of 1983 (NAD83).

Site Id	Grid Id	Longitude	Latitude	UTM Easting	UTM Northing	UTM Zone
Flux Tower Sites						
Southern Study Area:						
SSA-FEN-MMR01	F0L9T	104.61798° W	53.80206° N	525159.8	5961566.6	13
SSA-OBS-MMR01	G8I4T	105.11779° W	53.98717° N	492276.5	5982100.5	13
SSA-OJP-MMR01	G2L3T	104.69203° W	53.91634° N	520227.7	5974257.5	13
SSA-YJP-MMR01	F8L6T	104.64529° W	53.87581° N	523320.2	5969762.5	13
SSA-9OA-MMR01	C3B7T	106.19779° W	53.62889° N	420790.5	5942899.9	13
SSA-9YA-MMR01	D0H4T	105.32314° W	53.65601° N	478644.1	5945298.9	13
Northern Study Area:						
NSA-OBS-MMR01	T3R8T	98.48139° W	55.88007° N	532444.5	6192853.4	14
NSA-OJP-MMR01	T7Q8T	98.62396° W	55.92842° N	523496.2	6198176.3	14
NSA-YJP-MMR01	T8S9T	98.28706° W	55.89575° N	544583.9	6194706.9	14
NSA-BVP-MMR01	T4U6T	98.02747° W	55.84225° N	560900.6	6188950.7	14
NSA-FEN-MMR01	T7S1T	98.42072° W	55.91481° N	536207.9	6196749.6	14
Auxiliary Sites						
Southern Study Area:						
SSA-9BS-MMR01	D0H6S	105.29534° W	53.64877° N	480508.7	5944263.4	13
SSA-9BS-MMR01	G2I4S	105.13964° W	53.93021° N	490831.4	5975766.3	13
SSA-9BS-MMR01	G2L7S	104.63785° W	53.90349° N	523793.6	5972844.3	13
SSA-9BS-MMR01	G6K8S	104.75900° W	53.94446° N	515847.9	5977146.9	13
SSA-9BS-MMR01	G9I4S	105.11805° W	53.99877° N	492291.2	5983169.1	13
SSA-9JP-MMR01	F5I6P	105.11175° W	53.86608° N	492651.3	5968627.1	13
SSA-9JP-MMR01	F7J0P	105.05115° W	53.88336° N	496667.0	5970323.3	13
SSA-9JP-MMR01	F7J1P	105.03226° W	53.88211° N	497879.4	5970405.6	13
SSA-9JP-MMR01	G1K9P	104.74812° W	53.90880° N	516546.7	5973404.5	13
SSA-9JP-MMR01	G4K8P	104.76401° W	53.91883° N	515499.1	5974516.6	13
SSA-9JP-MMR01	G7K8P	104.77148° W	53.95882° N	514994.2	5978963.8	13
SSA-9JP-MMR01	G8L6P	104.63755° W	53.96558° N	523778.0	5979752.7	13
SSA-9JP-MMR01	G9L0P	104.73779° W	53.97576° N	517197.7	5980856.0	13
SSA-9JP-MMR01	I2I8P	105.05107° W	54.11181° N	496661.4	5995963.1	13
SSA-ASP-MMR01	B9B7A	106.18693° W	53.59098° N	421469.8	5938447.2	13
SSA-ASP-MMR01	D6H4A	105.31546° W	53.70828° N	479177.5	5951112.1	13
SSA-ASP-MMR01	D6L9A	104.63880° W	53.66879° N	523864.0	5946733.2	13
SSA-ASP-MMR01	D9G4A	105.46929° W	53.74019° N	469047.1	5954718.4	13
SSA-MIX-MMR01	D9I1M	105.20643° W	53.72540° N	486379.7	5952989.7	13
SSA-MIX-MMR01	F1N0M	104.53300° W	53.80594° N	530753.7	5962031.8	13
SSA-MIX-MMR01	G4I3M	105.14246° W	53.93750° N	490677.3	5976354.9	13

Site Id	Grid Id	Longitude	Latitude	UTM Easting	UTM Northing	UTM Zone
Northern Study Area:						
NSA-9BS-MMR01	S8W0S	97.84024° W	55.76824° N	572761.9	6180894.9	14
NSA-9BS-MMR01	T0P7S	98.82345° W	55.88371° N	511043.9	6193151.1	14
NSA-9BS-MMR01	T0P8S	98.80225° W	55.88351° N	512370.1	6193132.0	14
NSA-9BS-MMR01	T0W1S	97.80937° W	55.78239° N	574671.7	6182502.0	14
NSA-9BS-MMR01	T3U9S	97.98339° W	55.83083° N	563679.1	6187719.2	14
NSA-9BS-MMR01	T4U8S	97.99325° W	55.83913° N	563048.2	6188633.4	14
NSA-9BS-MMR01	T4U9S	97.98364° W	55.83455° N	563657.5	6188132.8	14
NSA-9BS-MMR01	T5Q7S	98.64022° W	55.91610° N	522487.2	6196800.5	14
NSA-9BS-MMR01	T6R5S	98.51865° W	55.90802° N	530092.0	6195947.0	14
NSA-9BS-MMR01	T6T6S	98.18658° W	55.87968° N	550887.9	6192987.9	14
NSA-9BS-MMR01	T7R9S	98.44877° W	55.91506° N	534454.5	6196763.6	14
NSA-9BS-MMR01	T7T3S	98.22621° W	55.89358° N	548391.8	6194505.6	14
NSA-9BS-MMR01	T8S4S	98.37111° W	55.91689° N	539306.4	6197008.6	14
NSA-9BS-MMR01	U5W5S	97.70986° W	55.90610° N	580655.5	6196380.8	14
NSA-9BS-MMR01	U6W5S	97.70281° W	55.91021° N	581087.8	6196846.5	14
NSA-9JP-MMR01	99O9P	99.03952° W	55.88173° N	497527.8	6192917.5	14
NSA-9JP-MMR01	Q3V3P	98.02473° W	55.55712° N	561517.9	6157222.2	14
NSA-9JP-MMR01	T7S9P	98.30037° W	55.89486° N	543752.4	6194599.1	14
NSA-9JP-MMR01	T8Q9P	98.61050° W	55.93219° N	524334.5	6198601.4	14
NSA-9JP-MMR01	T8S9P	98.28385° W	55.90456° N	544774.3	6195688.9	14
NSA-9JP-MMR01	T8T1P	98.26269° W	55.90539° N	546096.3	6195795.3	14
NSA-9JP-MMR01	T9Q8P	98.59568° W	55.93737° N	525257.1	6199183.2	14
NSA-9OA-MMR01	T2Q6A	98.67479° W	55.88691° N	520342.0	6193540.7	14
NSA-ASP-MMR01	P7V1A	98.07478° W	55.50253° N	558442.1	6151103.7	14
NSA-ASP-MMR01	Q3V2A	98.02635° W	55.56227° N	561407.9	6157793.5	14
NSA-ASP-MMR01	R8V8A	97.89260° W	55.67779° N	569638.4	6170774.8	14
NSA-ASP-MMR01	S9P3A	98.87621° W	55.88576° N	507743.3	6193371.6	14
NSA-ASP-MMR01	T4U5A	98.04329° W	55.84757° N	559901.6	6189528.2	14
NSA-ASP-MMR01	T8S4A	98.37041° W	55.91856° N	539348.3	6197194.6	14
NSA-ASP-MMR01	V5X7A	97.48565° W	55.97396° N	594506.1	6204216.6	14
NSA-ASP-MMR01	W0Y5A	97.33550° W	56.00339° N	603796.6	6207706.6	14
NSA-MIX-MMR01	Q1V2M	98.03769° W	55.54568° N	560718.3	6155937.3	14
NSA-MIX-MMR01	T0P5M	98.85662° W	55.88911° N	508967.7	6193747.3	14

7.1.2 Spatial Coverage Map

Not available.

7.1.3 Spatial Resolution

At 300 m altitude, the 15-degree FOV of the MMR yielded a ground resolution of approximately 79 m.

7.1.4 Projection

Not applicable.

7.1.5 Grid Description

Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

Measurements were collected as conditions permitted during each IFC. Observations were made during all three BOREAS 1994 IFCs.

- IFC-1 24-May - 16-June
- IFC-2 19-July - 10-August
- IFC-3 30-August - 19-September

7.2.2 Temporal Coverage Map

Observations were made at several sites on the following dates:

Date	Study Area
31-May-1994	SSA
01-Jun-1994	SSA
04-Jun-1994	SSA
06-Jun-1994	SSA
07-Jun-1994	SSA
08-Jun-1994	NSA
10-Jun-1994	NSA
21-Jul-1994	NSA
22-Jul-1994	SSA
23-Jul-1994	SSA
24-Jul-1994	SSA
25-Jul-1994	SSA
28-Jul-1994	SSA
04-Aug-1994	NSA
08-Aug-1994	NSA
06-Sep-1994	NSA
08-Sep-1994	NSA
09-Sep-1994	NSA
13-Sep-1994	NSA
15-Sep-1994	SSA
16-Sep-1994	SSA

7.2.3 Temporal Resolution

Measurements were collected as conditions permitted during each IFC. In general, the helicopter would hover 1-2 minutes for each observation (consisting of an average number of 20-25 scans). Each site was visited as often as possible during each IFC, with priority given to tower flux sites and category 1 auxiliary sites. Helicopter flight time was limited to approximately 2 hours by fuel constraints. As many sites as possible were visited during each flight.

7.3 Data Characteristics

7.3.1 Parameter/Variable

The parameters contained in the data files on the CD-ROM are:

```
         Column Name
------------------------------
SITE_NAME
SUB_SITE
OP_GRID_ID
DATE_OBS
START_TIME
END_TIME
SOLAR_ZEN_ANG
SOLAR_AZ_ANG
PLATFORM_ALTITUDE
MEAN_MMR_CH1_RAD
SDEV_MMR_CH1_RAD
MEAN_MMR_CH1_REFL
MEAN_MMR_CH2_RAD
SDEV_MMR_CH2_RAD
MEAN_MMR_CH2_REFL
MEAN_MMR_CH3_RAD
SDEV_MMR_CH3_RAD
MEAN_MMR_CH3_REFL
MEAN_MMR_CH4_RAD
SDEV_MMR_CH4_RAD
MEAN_MMR_CH4_REFL
MEAN_MMR_CH5_RAD
SDEV_MMR_CH5_RAD
MEAN_MMR_CH5_REFL
MEAN_MMR_CH6_RAD
SDEV_MMR_CH6_RAD
MEAN_MMR_CH6_REFL
MEAN_MMR_CH7_RAD
SDEV_MMR_CH7_RAD
MEAN_MMR_CH7_REFL
MEAN_MMR_CH8_RAD
SDEV_MMR_CH8_RAD
MEAN_BRIGHTNESS_TEMP
SDEV_BRIGHTNESS_TEMP
INTERP_AEROSOL_OPT_THICK_550
COLUMN_WATER_VAPOR
MEAN_CHOPPER_TEMP
SDEV_CHOPPER_TEMP
MEAN_DETECTOR_TEMP
SDEV_DETECTOR_TEMP
REVISION_DATE
CRTFCN_CODE
```

7.3.2 Variable Description/Definition

The descriptions of the parameters contained in the data files on the CD-ROM are:

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
OP_GRID_ID	The identifier given to the BOREAS auxiliary and tower sites during the execution of field operations. An example of this is B9B7A.
DATE_OBS	The date on which the data were collected.
START_TIME	The starting Greenwich Mean Time (GMT) for the data collected.
END_TIME	The ending Greenwich Mean Time (GMT) for the data collected.
SOLAR_ZEN_ANG	The angle from the surface normal (straight up) to the sun during the data collection.
SOLAR_AZ_ANG	Direction referred to as a circular scale of degrees read clockwise describing the position of the sun where 0=north, 90=east, 180=south and 270=west.
PLATFORM_ALTITUDE	The nominal altitude of the data collection platform above the target.
MEAN_MMR_CH1_RAD	The mean reflected radiance at this site from the Barnes MMR channel 1 (.45-.52 microns).
SDEV_MMR_CH1_RAD	The standard deviation of the reflected radiance for MMR channel 1.
MEAN_MMR_CH1_REFL	The mean reflectance factor at this site for MMR channel 1.
MEAN_MMR_CH2_RAD	The mean reflected radiance at this site from the Barnes MMR channel 2 (.52 - .60 microns).
SDEV_MMR_CH2_RAD	The standard deviation of the reflected radiance for MMR channel 2.
MEAN_MMR_CH2_REFL	The mean reflectance factor at this site for MMR channel 2.
MEAN_MMR_CH3_RAD	The mean reflected radiance at this site from the Barnes MMR channel 3 (.63-.68 microns).
SDEV_MMR_CH3_RAD	The standard deviation of the reflected radiance for MMR channel 3.
MEAN_MMR_CH3_REFL	The mean reflectance factor at this site for MMR channel 3.
MEAN_MMR_CH4_RAD	The mean reflected radiance at this site from the Barnes MMR channel 4 (.75-.80 microns).

SDEV_MMR_CH4_RAD	The standard deviation of the reflected radiance for MMR channel 4.
MEAN_MMR_CH4_REFL	The mean reflectance factor at this site for MMR channel 4.
MEAN_MMR_CH5_RAD	The mean reflected radiance at this site from the Barnes MMR channel 5 (1.17-1.33 microns).
SDEV_MMR_CH5_RAD	The standard deviation of the reflected radiance for MMR channel 5.
MEAN_MMR_CH5_REFL	The mean reflectance factor at this site for MMR channel 5.
MEAN_MMR_CH6_RAD	The mean reflected radiance at this site from the Barnes MMR channel 6 (1.57-1.80 microns).
SDEV_MMR_CH6_RAD	The standard deviation of the reflected radiance for MMR channel 6.
MEAN_MMR_CH6_REFL	The mean reflectance factor at this site for MMR channel 6.
MEAN_MMR_CH7_RAD	The mean reflected radiance at this site from the Barnes MMR channel 7 (2.08-2.37 microns).
SDEV_MMR_CH7_RAD	The standard deviation of the reflected radiance for MMR channel 7.
MEAN_MMR_CH7_REFL	The mean reflectance factor at this site for MMR channel 7.
MEAN_MMR_CH8_RAD	The mean emitted radiance at this site from the Barnes MMR channel 8 (10.4-12.3 microns).
SDEV_MMR_CH8_RAD	The standard deviation of the radiance for MMR channel 8.
MEAN_BRIGHTNESS_TEMP	The mean at-sensor brightness temperature from MMR channel 8.
SDEV_BRIGHTNESS_TEMP	The standard deviation of the at-sensor brightness temperature.
INTERP_AEROSOL_OPT_THICK_550	The aerosol optical depth interpolated to 550 nanometers, used in the atmospheric correction.
COLUMN_WATER_VAPOR	The amount of precipitable water within a vertical column of air with a cross-section of 1 centimeter squared and a fixed depth (usually from the ground to the top of the atmosphere).
MEAN_CHOPPER_TEMP	The mean Barnes MMR chopper temperature.
SDEV_CHOPPER_TEMP	The standard deviation of the radiometer chopper temperature.
MEAN_DETECTOR_TEMP	The mean detector temperature.
SDEV_DETECTOR_TEMP	Standard deviation of the detector temperature.
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).

*** Note: MMR 8 data are NOT atmospherically corrected ***

7.3.3 Unit of Measurement

The measurement units for the parameters contained in the data files on the CD-ROM are:

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
OP_GRID_ID	[none]
DATE_OBS	[DD-MON-YY]
START_TIME	[HHMM GMT]
END_TIME	[HHMM GMT]
SOLAR_ZEN_ANG	[degrees]
SOLAR_AZ_ANG	[degrees]
PLATFORM_ALTITUDE	[meters]
MEAN_MMR_CH1_RAD	[Watts][meter^-2][steradian^-1][micrometer^-1]
SDEV_MMR_CH1_RAD	[Watts][meter^-2][steradian^-1][micrometer^-1]
MEAN_MMR_CH1_REFL	[percent]
MEAN_MMR_CH2_RAD	[Watts][meter^-2][steradian^-1][micrometer^-1]
SDEV_MMR_CH2_RAD	[Watts][meter^-2][steradian^-1][micrometer^-1]
MEAN_MMR_CH2_REFL	[percent]
MEAN_MMR_CH3_RAD	[Watts][meter^-2][steradian^-1][micrometer^-1]
SDEV_MMR_CH3_RAD	[Watts][meter^-2][steradian^-1][micrometer^-1]
MEAN_MMR_CH3_REFL	[percent]
MEAN_MMR_CH4_RAD	[Watts][meter^-2][steradian^-1][micrometer^-1]
SDEV_MMR_CH4_RAD	[Watts][meter^-2][steradian^-1][micrometer^-1]
MEAN_MMR_CH4_REFL	[percent]
MEAN_MMR_CH5_RAD	[Watts][meter^-2][steradian^-1][micrometer^-1]
SDEV_MMR_CH5_RAD	[Watts][meter^-2][steradian^-1][micrometer^-1]
MEAN_MMR_CH5_REFL	[percent]
MEAN_MMR_CH6_RAD	[Watts][meter^-2][steradian^-1][micrometer^-1]
SDEV_MMR_CH6_RAD	[Watts][meter^-2][steradian^-1][micrometer^-1]
MEAN_MMR_CH6_REFL	[percent]
MEAN_MMR_CH7_RAD	[Watts][meter^-2][steradian^-1][micrometer^-1]
SDEV_MMR_CH7_RAD	[Watts][meter^-2][steradian^-1][micrometer^-1]
MEAN_MMR_CH7_REFL	[percent]
MEAN_MMR_CH8_RAD	[Watts][meter^-2][steradian^-1][micrometer^-1]
SDEV_MMR_CH8_RAD	[Watts][meter^-2][steradian^-1][micrometer^-1]
MEAN_BRIGHTNESS_TEMP	[degrees Celsius]
SDEV_BRIGHTNESS_TEMP	[degrees Celsius]
INTERP_AEROSOL_OPT_THICK_550	[unitless]
COLUMN_WATER_VAPOR	[millimeters]
MEAN_CHOPPER_TEMP	[degrees Celsius]
SDEV_CHOPPER_TEMP	[degrees Celsius]
MEAN_DETECTOR_TEMP	[degrees Celsius]
SDEV_DETECTOR_TEMP	[degrees Celsius]
REVISION_DATE	[DD-MON-YY]
CRTFCN_CODE	[none]

7.3.4 Data Source

The sources of the parameter values contained in the data files on the CD-ROM are:

Column Name	Data Source
SITE_NAME	[Assigned by BORIS Staff]
SUB_SITE	[Assigned by BORIS Staff]
OP_GRID_ID	[Assigned by BORIS Staff]
DATE_OBS	[Controller]
START_TIME	[Controller]
END_TIME	[Controller]
SOLAR_ZEN_ANG	[Calculated by software]
SOLAR_AZ_ANG	[Calculated by software]
PLATFORM_ALTITUDE	[NASA Helicopter]
MEAN_MMR_CH1_RAD	[Barnes Modular Multiband Radiometer (MMR)]
SDEV_MMR_CH1_RAD	[Calculated by software]
MEAN_MMR_CH1_REFL	[Calculated by software]
MEAN_MMR_CH2_RAD	[Barnes Modular Multiband Radiometer (MMR)]
SDEV_MMR_CH2_RAD	[Calculated by software]
MEAN_MMR_CH2_REFL	[Calculated by software]
MEAN_MMR_CH3_RAD	[Barnes Modular Multiband Radiometer (MMR)]
SDEV_MMR_CH3_RAD	[Calculated by software]
MEAN_MMR_CH3_REFL	[Calculated by software]
MEAN_MMR_CH4_RAD	[Barnes Modular Multiband Radiometer (MMR)]
SDEV_MMR_CH4_RAD	[Calculated by software]
MEAN_MMR_CH4_REFL	[Calculated by software]
MEAN_MMR_CH5_RAD	[Barnes Modular Multiband Radiometer (MMR)]
SDEV_MMR_CH5_RAD	[Calculated by software]
MEAN_MMR_CH5_REFL	[Calculated by software]
MEAN_MMR_CH6_RAD	[Barnes Modular Multiband Radiometer (MMR)]
SDEV_MMR_CH6_RAD	[Calculated by software]
MEAN_MMR_CH6_REFL	[Calculated by software]
MEAN_MMR_CH7_RAD	[Barnes Modular Multiband Radiometer (MMR)]
SDEV_MMR_CH7_RAD	[Calculated by software]
MEAN_MMR_CH7_REFL	[Calculated by software]
MEAN_MMR_CH8_RAD	[Barnes Modular Multiband Radiometer (MMR)]
SDEV_MMR_CH8_RAD	[Calculated by software]
MEAN_BRIGHTNESS_TEMP	[Calculated by software]
SDEV_BRIGHTNESS_TEMP	[Calculated by software]
INTERP_AEROSOL_OPT_THICK_550	[RSS11 Sunphotometer]
COLUMN_WATER_VAPOR	[RSS11 Sunphotometer]
MEAN_CHOPPER_TEMP	[Calculated by software]
SDEV_CHOPPER_TEMP	[Calculated by software]
MEAN_DETECTOR_TEMP	[Calculated by software]
SDEV_DETECTOR_TEMP	[Calculated by software]
REVISION_DATE	[Assigned by BORIS Staff]
CRTFCN_CODE	[Assigned by BORIS Staff]

7.3.5 Data Range

The following table gives information about the parameter values found in the data files on the CD-ROM.

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	NSA-9BS-9TETR	SSA-YJP-FLXTR	None	None	None	None
SUB_SITE	RSS03-MMR01	RSS03-MMR01	None	None	None	None
OP_GRID_ID	B9B7A	W0Y5A	None	None	None	None
DATE_OBS	31-MAY-94	16-SEP-94	None	None	None	None
START_TIME	830	1629	None	None	None	None
END_TIME	833	1632	None	None	None	None
SOLAR_ZEN_ANG	32.167	63.215	None	None	None	None
SOLAR_AZ_ANG	96.059	248.965	None	None	None	None
PLATFORM_ALTITUDE	91.4	304.8	None	None	None	None
MEAN_MMR_CH1_RAD	4.328	19.413	None	None	None	None
SDEV_MMR_CH1_RAD	.067	1.256	None	None	None	None
MEAN_MMR_CH1_REFL	0	4.2	None	None	None	None
MEAN_MMR_CH2_RAD	5.19	24.375	None	None	None	None
SDEV_MMR_CH2_RAD	.088	1.733	None	None	None	None
MEAN_MMR_CH2_REFL	1.0	6.5	None	None	None	None
MEAN_MMR_CH3_RAD	3.797	21.419	None	None	None	None
SDEV_MMR_CH3_RAD	.058	1.531	None	None	None	None
MEAN_MMR_CH3_REFL	1.0	7.1	None	None	None	None
MEAN_MMR_CH4_RAD	14.828	97.359	None	None	None	None
SDEV_MMR_CH4_RAD	.285	5.01	None	None	None	None
MEAN_MMR_CH4_REFL	6.2	38.5	None	None	None	None
MEAN_MMR_CH5_RAD	3.835	36.052	None	None	None	None
SDEV_MMR_CH5_RAD	.109	1.525	None	None	None	None
MEAN_MMR_CH5_REFL	5.4	38.7	None	None	None	None
MEAN_MMR_CH6_RAD	.618	11.27	None	None	None	None
SDEV_MMR_CH6_RAD	.034	.568	None	None	None	None
MEAN_MMR_CH6_REFL	1.7	22.9	None	None	None	None
MEAN_MMR_CH7_RAD	.14	2.353	None	None	None	None
SDEV_MMR_CH7_RAD	.006	.124	None	None	None	None
MEAN_MMR_CH7_REFL	1.2	12.6	None	None	None	None
MEAN_MMR_CH8_RAD	5.588	22.448	None	None	None	None
SDEV_MMR_CH8_RAD	.027	4.695	None	None	None	None
MEAN_BRIGHTNESS_TEMP	-5.067	102.3	None	None	None	None
SDEV_BRIGHTNESS_TEMP	.216	28.435	None	None	None	None
INTERP_AEROSOL_OPT_ THICK_550	.0291	.6388	None	None	None	None
COLUMN_WATER_VAPOR	7.05	25.83	None	None	None	None
MEAN_CHOPPER_TEMP	1.073	24.267	None	None	None	None
SDEV_CHOPPER_TEMP	.005	.379	None	None	None	None
MEAN_DETECTOR_TEMP	9.307	47.14	None	None	None	None
SDEV_DETECTOR_TEMP	.001	.667	None	None	None	None
REVISION_DATE	01-MAY-98	01-MAY-98	None	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None

Minimum Data Value -- The minimum value found in the column.
Maximum Data Value -- The maximum value found in the column.
Missng Data Value -- The value that indicates missing data. This is used to

```
                      indicate that an attempt was made to determine the
                      parameter value, but the attempt was unsuccessful.
Unrel Data Value   -- The value that indicates unreliable data.  This is used
                      to indicate an attempt was made to determine the
                      parameter value, but the value was deemed to be
                      unreliable by the analysis personnel.
Below Detect Limit -- The value that indicates parameter values below the
                      instruments detection limits.  This is used to
                      indicate that an attempt was made to determine the
                      parameter value, but the analysis personnel determined
                      that the parameter value was below the detection
                      limit of the instrumentation.
Data Not Cllctd    -- This value indicates that no attempt was made to
                      determine the parameter value.  This usually
                      indicates that BORIS combined several similar but
                      not identical data sets into the same data base table
                      but this particular science team did not
                      measure that parameter.

Blank -- Indicates that blank spaces are used to denote that type of value.
N/A   -- Indicates that the value is not applicable to the respective column.
None  -- Indicates that no values of that sort were found in the column.
--------------------------------------------------------------------------------
```

7.4 Sample Data Record

The following is a sample of the first few records from the data table on the CD-ROM:

```
SITE_NAME,SUB_SITE,DATE_OBS,OP_GRID_ID,START_TIME,END_TIME,SOLAR_ZEN_ANG,
SOLAR_AZ_ANG,PLATFORM_ALTITUDE,MEAN_MMR_CH1_RAD,SDEV_MMR_CH1_RAD,
MEAN_MMR_CH1_REFL,MEAN_MMR_CH2_RAD,SDEV_MMR_CH2_RAD,MEAN_MMR_CH2_REFL,
MEAN_MMR_CH3_RAD,SDEV_MMR_CH3_RAD,MEAN_MMR_CH3_REFL,MEAN_MMR_CH4_RAD,
SDEV_MMR_CH4_RAD,MEAN_MMR_CH4_REFL,MEAN_MMR_CH5_RAD,SDEV_MMR_CH5_RAD,
MEAN_MMR_CH5_REFL,MEAN_MMR_CH6_RAD,SDEV_MMR_CH6_RAD,MEAN_MMR_CH6_REFL,
MEAN_MMR_CH7_RAD,SDEV_MMR_CH7_RAD,MEAN_MMR_CH7_REFL,MEAN_MMR_CH8_RAD,
SDEV_MMR_CH8_RAD,MEAN_BRIGHTNESS_TEMP,SDEV_BRIGHTNESS_TEMP,
INTERP_AEROSOL_OPT_THICK_550,COLUMN_WATER_VAPOR,MEAN_CHOPPER_TEMP,
SDEV_CHOPPER_TEMP,MEAN_DETECTOR_TEMP,SDEV_DETECTOR_TEMP,REVISION_DATE,CRTFCN_CODE
'SSA-ASP-AUX02','RSS03-MMR01',31-MAY-94,'B9B7A',922,923,51.83,105.375,304.8,
7.565,.229,1.5,12.582,.306,3.6,6.718,.274,2.2,59.392,1.564,30.9,21.811,.435,
28.6,6.255,.111,15.7,.75,.023,5.4,7.94,.044,15.995,.354,.0709,9.56,10.502,.01,
12.216,.006,01-MAY-98,'CPI'
'SSA-OJP-FLXTR','RSS03-MMR01',31-MAY-94,'G2L3T',1017,1019,43.681,121.201,
304.8,13.902,.424,2.8,17.234,.493,4.2,15.023,.475,4.5,33.538,.556,14.8,16.552,
.28,18.4,6.49,.165,13.9,1.168,.04,7.2,8.236,.052,18.373,.415,.0734,10.03,10.387,
.066,11.958,.047,01-MAY-98,'CPI'
'SSA-YJP-FLXTR','RSS03-MMR01',31-MAY-94,'F8L6T',1029,1030,42.182,124.601,
304.8,12.435,.393,2.4,16.48,.513,3.9,14.596,.489,4.3,41.367,1.196,17.8,20.497,
.339,22.2,7.826,.196,16.3,1.394,.046,8.3,8.66,.059,21.7,.459,.0734,10.03,11.254,
.029,12.847,.023,01-MAY-98,'CPI'
```

8. Data Organization

The smallest unit of data that is tracked by the BOREAS Information System (BORIS) is all of the data for a given day at a given site.

8.2 Data Format(s)

The Compact Disk-Read Only Memory (CD-ROM) files contain American Standard Code for Information Interchange (ASCII) numerical and character fields of varying length separated by commas. The character fields are enclosed with single apostrophe marks. There are no spaces between the fields.

Each data file on the CD-ROM has four header lines of Hyper-Text Markup Language (HTML) code at the top. When viewed with a Web browser, this code displays header information (data set title, location, date, acknowledgments, etc.) and a series of HTML links to associated data files and related data sets. Line 5 of each data file is a list of the column names, and line 6 and following lines contain the actual data.

9. Data Manipulations

9.1 Formulae

9.1.1 Derivation Techniques and Algorithms

The approach used to calculate at surface reflectance comes from Vermote et al. (1997):

"Two atmospheric processes modify the solar radiance reflected by a target when viewed from space: absorption by the gases (when observation bands are overlapping gaseous absorption bands) and scattering by the aerosols and the molecules. If the gaseous absorption can be de-coupled from scattering as if the absorbents were located above the scattering layers, as assumed in the 6S code, the equation of transfer for a Lambertian homogeneous target of reflectance P_SFC at sea level altitude viewed by a satellite sensor (under zenith angle of view theta_v and azimuth angle of view phi_v) and illuminated by sun (theta_s, phi_s) is:

P_TOA(theta_s, theta_v, phi_s-phi_v) = T_g(theta_s, theta_v) * [P_R+A + T_dn(theta_s) *
T_up(theta_v) * {P_SFC / (1 - S*P_SFC)}].   (1)

The various quantities are expressed in terms of equivalent reflectance P defined as P = pi * L /mu_s* E_s where L is the measured radiance, E_s is the solar flux at the top of the atmosphere, and mu_s = cos(theta_s) where theta_s is the solar zenith angle."

In addition, note the following notation (Vermote et al., 1997):

```
T_g     Gaseous transmission of water vapor, carbon dioxide,
        oxygen, and ozone.
P_TOA   Reflectance at the top of the atmosphere.
P_R+A   Intrinsic reflectance of the molecule+aerosol layer.
T_dn    Total transmission of the atmosphere on the path
        between the sun and the surface.
T_up    Total transmission of the atmosphere on the path
        between the surface and the sensor.
S       Spherical albedo of the atmosphere.
```

9.2 Data Processing Sequence

9.2.1 Processing Steps

The seven spectral bands of the MMR used in this data set are: 0.45-0.52 µm (MMR1-blue), 0.51-0.52 µm (MMR2-green), 0.63-0.68 µm (MMR3-red), 0.75-0.88 µm (MMR4-near-infrared or infrared), 1.17-1.33 µm (MMR5-first middle infrared), 1.57-1.80 µm (MMR6-second middle infrared), and 2.08-2.37 µm (MMR7-farthest middle infrared). The MMR sensor voltages were processed to at-sensor radiance (W/m^2 µm sr) following procedures described in Markham et al. (1988). Calibration coefficients were obtained before and after the deployment at NASA GSFC and onsite during the deployment using a portable calibration apparatus. The individual data scans were examined and the obvious spurious values were removed. The mean helicopter MMR radiances, along with near-simultaneous sunphotometer data collected by the Remote Sensing Science (RSS)-11 automated ground network, were then input into Version 3.2 of 6S (Vermote et al., 1997) to obtain at-surface reflectance factors corrected for atmospheric effects. The 6S software is public domain and available via anonymous ftp at kratmos.gsfc.nasa.gov. The RSS-11 surface-based network of sunphotometers provided estimates of aerosol optical depths, which varied spatially and temporally, especially during the summer, due to the prevalence of smoke from forest fires. Sunphotometer measurements taken from the helicopter platform at data collection altitudes were not available at the time of this analysis.

9.2.2 Processing Changes

None.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

None.

9.3.2 Calculated Variables

At-sensor and at-surface reflectance factors.

9.4 Graphs and Plots

None.

10. Errors

10.1 Sources of Error

Potential sources of error include radiometric calibration; spectral calibration; physical (environmental and human) conditions (including helicopter vibration, minor changes in helicopter altitude and inclination); atmospheric conditions, including atmospheric parameters estimated from the surface sunphotometer network; and the atmospheric correction algorithm (Vermote et al., 1997).

10.2 Quality Assessment

10.2.1 Data Validation by Source

Visual quality assessment was performed during data collection. See reference list and helicopter logs.

10.2.2 Confidence Level/Accuracy Judgment

A thorough quantitative error analysis is given in Markham et al (1988).

10.2.3 Measurement Error for Parameters

Confidence intervals for the at-sensor radiance values presented in this data set are within 3% of actual for the visible/near-infrared, 5% of actual for the mid-infrared, and +/- 5-6% for MMR channel 8. The possibility of errors being introduced into the data set increases with additional manipulations of the data. For an in-depth discussion of error considerations, see Markham et al. (1988).

10.2.4 Additional Quality Assessments

A complete quality assessment is provided in the helicopter logs. In addition, see Walthall et al. (1997).

10.2.5 Data Verification by Data Center

BORIS personnel have performed some quality checks of the data in the process of loading the data into the data base. A subset of site information has been extracted and compared with TM reflectance values.

11. Notes

11.1 Limitations of the Data

Data collected over sparse canopies and with extreme solar geometry (i.e., early morning/late afternoon observations) will contain substantial amounts of shadow, which may complicate the retrieval of surface vegetation parameters.

In addition, isolated atmospheric events (such as forest fires or scattered cloudiness) reduce the certainty in the atmospheric correction. The use of surface-measured atmospheric variables contributes to error in the data set in those cases.

11.2 Known Problems with the Data

A few spurious values are present in the data for MMR channel 8; the problems associated with these values have not yet been ascertained. In addition, helicopter data logs for IFCs 1, 2, and 3 are available.

Input solar geometry (solar zenith angle and azimuth) used in Vermote et al. (1997) atmospheric correction is in error by -1 hour for 08-June-1994 Flight A observations.

11.3 Usage Guidance

None given.

11.4 Other Relevant Information

See helicopter logs.

12. Application of the Data Set

Research questions that may be examined with these data include:

- Retrieval of leaf area index (LAI) from spectral vegetation index.
- Scaling of spectral response in boreal regions (in combination with other BOREAS data sets).

13. Future Modifications and Plans

None.

14. Software

14.1 Software Description

The software used in the atmospheric correction of this data set was 6S, Version 3.2 (Vermote et al., 1997).

14.2 Software Access

This software is public domain and available via anonymous ftp at kratmos.gsfc.nasa.gov.

15. Data Access

The helicopter-based radiometric data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

15.1 Contact Information

For BOREAS data and documentation please contact:

ORNL DAAC User Services
Oak Ridge National Laboratory
P.O. Box 2008 MS-6407
Oak Ridge, TN 37831-6407
Phone: (423) 241-3952
Fax: (423) 574-4665
E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

15.2 Data Center Identification

Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics http://www-eosdis.ornl.gov/.

15.3 Procedures for Obtaining Data

Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] and the anonymous FTP site [ftp://www-eosdis.ornl.gov/data/] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

15.4 Data Center Status/Plans

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

16. Output Products and Availability

16.1 Tape Products

None.

16.2 Film Products

None.

16.3 Other Products

These data are available on the BOREAS CD-ROM series.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

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17.2 Journal Articles and Study Reports

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17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None given.

19. List of Acronyms

6S - Second Simulation of the Satellite Signal in the Solar Spectrum
A/D - Analog-to-digital
AGL - Above Ground Level
ASAS - Advanced Solid-state Array Spectroradiometer
ASCII - American Standard Code for Information Interchange
BOREAS - BOReal Ecosystem-Atmosphere Study
BORIS - BOREAS Information System
BRDF - Bidirectional Reflectance Distribution Function
BSQ - Band Sequential
BVP - Beaver Pond
CCD - Charge-Coupled Device
CD-ROM - Compact Disk-Read-Only Memory
DAAC - Distributed Active Archive Center
EOS - Earth Observing System
EOSDIS - EOS Data and Information System
FIFE - First ISLSCP Field Experiment
FOV - Field of View
GIS - Geographic Information System
GSFC - Goddard Space Flight Center
HTML - HyperText Markup Language
IFC - Intensive Field Campaign
IFOV - Instantaneous Field of View
ISLSCP - International Satellite Land Surface Climatology Project
LAI - Leaf Area Index
MMR - Modular Multiband Radiometer
NAD83 - North American Datum of 1983
NASA - National Aeronautics and Space Administration
NSA - Northern Study Area
OA - Old Aspen
OBS - Old Black Spruce
OJP - Old Jack Pine
ORNL - Oak Ridge National Laboratory
PANP - Prince Albert National Park
PARABOLA - Portable Apparatus for Rapid Acquisition of Bidirectional Observations of the Land and Atmosphere
POLDER - Polarization and Directionality of Earth's Reflectances
RSS - Remote Sensing Science
SE-590 - Spectron Engineering spectroradiometer
SSA - Southern Study Area
TM - Thematic Mapper
URL - Uniform Resource Locator
UTM - Universal Transverse Mercator
WFF - Wallops Flight Facility
YA - Young Aspen
YJP - Young Jack Pine

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13. ABSTRACT *(Maximum 200 words)*

The BOREAS RSS-3 team acquired helicopter-based radiometric measurements of forested sites with a Barnes MMR. The data were collected in 1994 during the three BOREAS IFCs at numerous tower and auxiliary sites in both the NSA and SSA. The 15-degree FOV of the MMR yielded approximately 79-m ground resolution from an altitude of 300 m. The MMR has seven spectral bands that are similar to the Landsat TM bands, ranging from the blue region to the thermal. The data are stored in tabular ASCII files. The data are stored in tabular ASCII files.

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